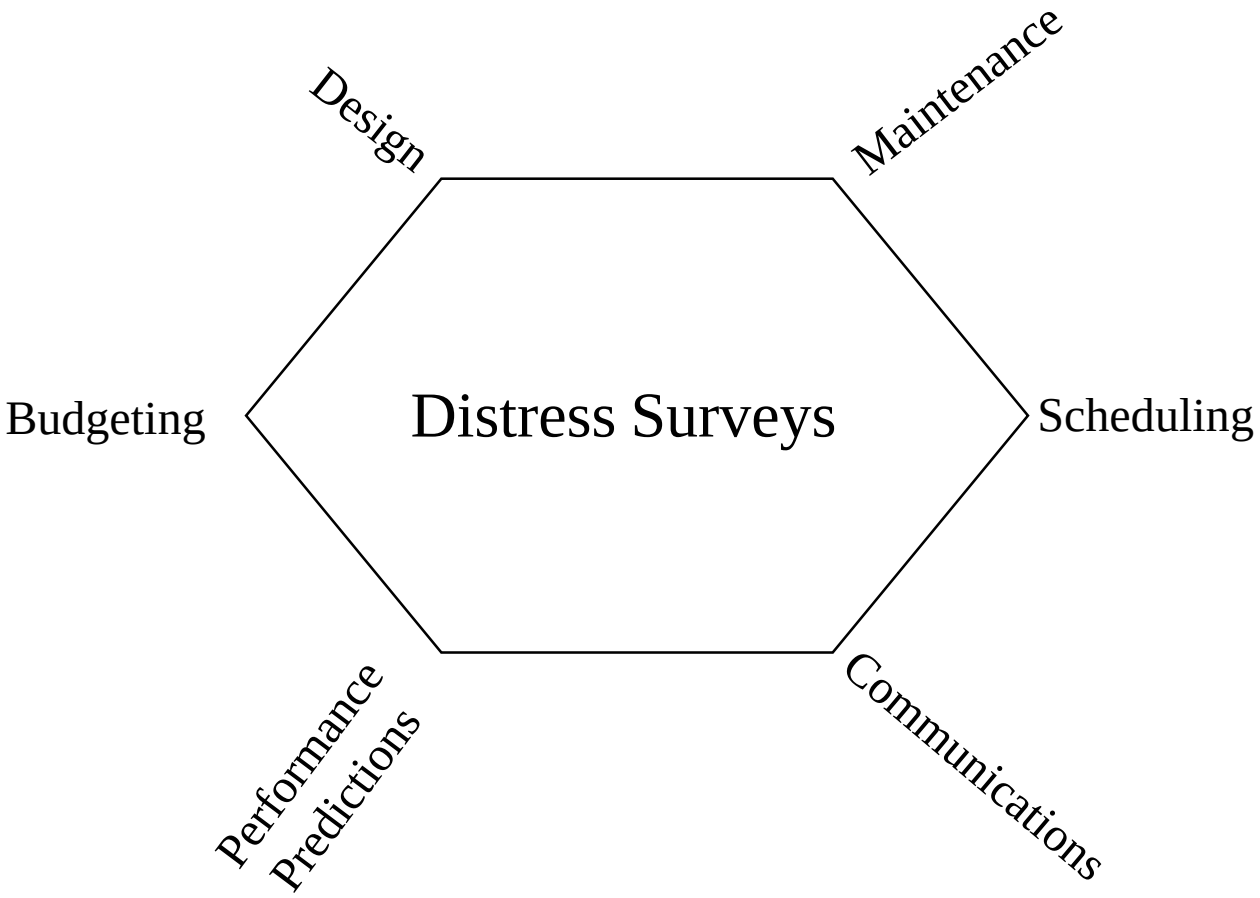
Maintenance and Pavement Management



FY 2003 UDOT Distress Manual
September 2002

Forward

This manual has been developed for training and use during the FY 2003 network distress surveys. Improvements in distress survey methods and condition ratings are expected to continuously evolve and will be incorporated into this manual by yearly changes. This manual describes the methods to be used for conducting visual evaluations of flexible and jointed concrete pavement distresses. It was formatted to be read and printed as an Adobe .pdf file.

The survey procedures provide a method of determining pavement condition through observation and recording the presence of specific types defects or distresses in the pavement surface.
The 3 elements of the pavement distress rating are as follows:
1. The **type** of distress.
2. The **severity** of the distress.
3. The **extent** to which the road surface is affected by the distress.
There may be several types of severity and extents for each distress. These are described and illustrated in the following pages of this manual.

The rating system was developed considering the following objectives: (1) to record conditions that can effect pavement performance, (2) to facilitate consistent results from several different individuals with limited survey experience observing and measuring from the shoulder of the pavement, and (3) cost effectiveness. Some conditions that can affect performance are not included because of the expected difficulty in achieving consistency among raters. The definitions of severity and extent could be different if the conditions were rated through the windshield when driving the road, were mapped, or determined from photo images.

Generally conditions will be surveyed in the outside travel lane in the positive direction (reference post numbers increasing in the direction of traffic). If safety or traffic require a different lane or direction, indicate in **comment field** when recording data.

Except for *Bleeding* and *Raveling*, record the extent of **each severity** of each type of distress. When rating the width of an individual crack, use the predominant or average width, not the extremes. Cracks often vary in width and the intent is to rate the overall severity of the crack. Severity is not rated for *Skin Patching, Potholes,* and *Edge Drop Off*.

The relative sun angle and direction of viewing the roadway surface can affect your visual observation. Be sure to view the pavement from more than one direction occasionally during the survey to assure the true nature of the pavement surface is being observed.

The time of year and weather (moisture and temperature) conditions over a given time period can also affect the severity and visibility of certain distresses. If practicable, rate the roadway only while the pavement is dry.

Field Safety

The safety of raters and motorists is of primary importance when surveying. Remember the following:

- **TURN ON THE VEHICLE FLASHING YELLOW LIGHT WHEN SURVEYING, TURN OFF WHEN NOT SURVEYING.**
- **HATS AND SAFETY VESTS WORN AT ALL TIMES.**
- **SURVEYS TO BE PERFORMED FROM THE ROADWAY SHOULDER**
- **ESTIMATE CRACK WIDTH FROM SHOULDER**

- **CONDUCT SURVEYS WITH ONE EYE ON TRAFFIC**
- **SUMMARIZE OUT OF HARM'S WAY**
- **DO NOT CHASE HATS OR FORMS**
- **DO NOT CONDUCT SURVEYS IN THE RAIN**

SAFETY FIRST

Survey Location

For flexible pavements, the survey shall be started at a **Reference Post** and shall continue **500 feet** in the direction of traffic. Reference Posts increase in number from south to north and from west to east. The survey distance and distress extent may be measured with a distance measuring instrument (DMI), a measuring wheel, or by pacing. The method of measurement shall be recorded for each location.

For rigid pavements, the survey shall be started at a reference post and shall continue **40 panels** (40 transverse) joints in the direction of traffic.

ALL SURVEY SECTIONS SHALL BE IN THE OUTSIDE TRAVEL LANE. The start of the survey sections may be offset to promote safety or to survey a more representative location. Example offset situations: survey section extends across an interstate off ramp, onto a bridge deck, or onto part of a patch. The **offset** relative a reference post shall be measured in feet and recorded in the **offset field** and the reason given in the **comment field**.

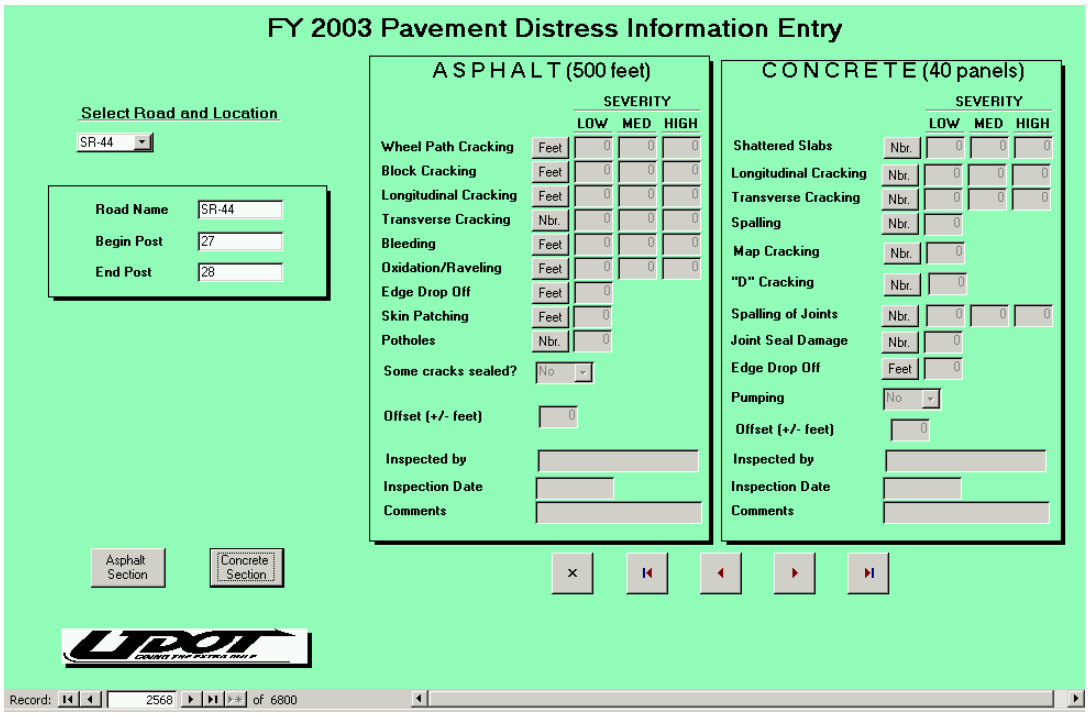
Going back and forth several times along the survey section may be required to measure the extent of several types of distress

Survey Forms

Blank and completed examples of paper survey forms are at the end of the manual.

Information from paper forms shall be transferred to an Access Database form similar to the following photo. Distress data may be directly entered into a laptop however it is expected that some type of recording on paper must be done at survey locations with two or more types of distress or varying extents.

An example of the computer form follows. Separate sections are provided for concrete and asphalt pavements. The survey locations are selected from drop-down menus. Inspection dates and surveyor name will default to the last entry. The adjacent survey sections can be accessed by using the arrow buttons below. The data entries will be saved when by changing sections.



Quality Control/Assurance

The quality of the surveys is dependent upon the training methods and reference materials, the appropriateness of definitions of severity and extent for survey methods, the conscientious efforts of the distress surveyors, and monitoring activities.

After training, the surveyors will be tested by recording the distresses at 5 locations determined by the Regional Pavement Management Engineers (RPME) or Central Pavement Management/ Planning and Statistics personnel. If the test sections are satisfactorily surveyed, as determined by following criteria, surveying of the network may start:

Type of Distress: 100% agreement
Severity: 75% agreement
Extent: 75% agreement

If the test sections are not satisfactorily surveyed, the RPME will provide personalized training until adequate skills are demonstrated.

The RPME will review the data collected during the first 3 days and check the results at select locations for each surveyor/team. The field review locations will be selected considering the different types of distress and the complexity of the severity and the extent. Unsatisfactory results will require more training or a change in personnel.

Upon completion of the network survey, Central Pavement Management and Planning and Statistics will evaluate the survey data with respect to pavement performance models, reproducibility and variation from preceding years. The data collection methods or definitions of severity and extent may be changed for the following year.

The RPME are responsible for the quality control of the survey data. Central Pavement Management and Planning and Statistics are responsible for the quality control of the survey process and data use.

DISTRESS TYPES FOR FLEXIBLE PAVEMENTS

Wheel Path Cracking
Longitudinal Cracking (Non Wheel Path)
Transverse Cracking
Block Cracking
Bleeding
Oxidation & Raveling
Skin Patching
Potholes (Optional)
Edge Drop Off > 1" Steeper than 3:1 (Optional)

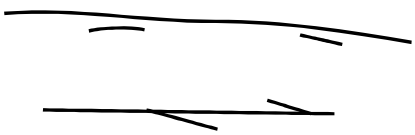
Definitions

A crack is considered **sealed** when its width cannot be determined.

Sealed

Unsealed

Secondary cracks are approximately parallel to and within 2 feet of or branch out from a predominant crack.



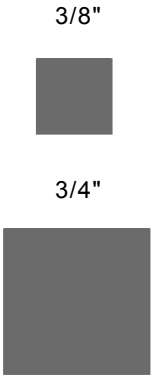
One longitudinal crack with secondary cracks

One transverse crack with a secondary crack

Spalling is material missing or chipping along a crack.

Construction Edge Joint Cracks are the longitudinal edges of asphalt layers laid down adjacent to each other. Construction joints are generally spaced 12 feet apart across the roadway width. The laydown width could be less from an outside edge. They are relatively straight or continuous compared to wheel path or longitudinal cracks. A construction edge joint in a wheel path will be rated as a longitudinal crack.

Crack width is the dimension of the opening across a crack. The widths of 3/8” and 3/4" are used to rate the **severity** of **longitudinal, transverse,** and **block cracks**.



low severity: < 3/8"

medium severity:
> 3/8" and < 3/4"

high severity: > 3/4"

Wheel Path Cracking

Description

Wheel path cracking results from vehicle loads. The cracks start initially as a series of parallel longitudinal cracks within the wheel path that progress with time and loads to a more branched pattern that begins to interconnect. Eventually the cracks interconnect sufficiently to form many pieces, resembling the pattern of alligator skin. The size of the pieces in a well-developed pattern are generally less than 12 inches in length. Frequently, the pattern of the cracking (the longer dimension of the connected cracks) is parallel to the roadway or direction of vehicle travel.

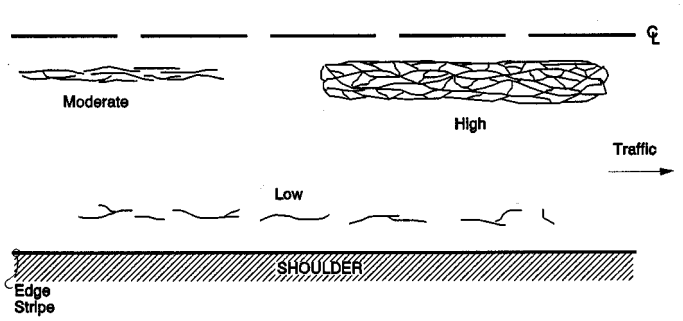
Wheel paths are typically 2 feet wide and are centered in the lane along straight-a-ways. On curves they commonly wonder toward the inside or outside of the lane. Bleeding or raveling mostly occur in the wheel paths and can indicate wheel path locations.

A **construction edge joint** in the wheel path, without an alligator pattern, shall be rated as a longitudinal crack.

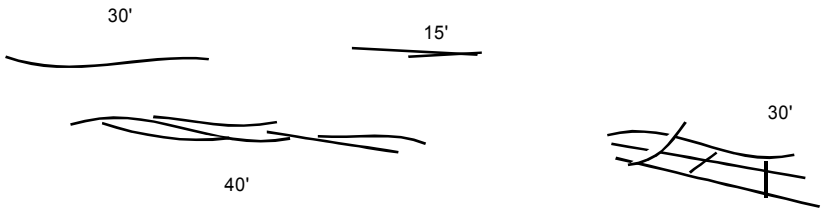
Severity

Its is rated according to pattern and material loss.

Low Severity	Medium Severity	High Severity
Longitudinal cracks with no or only a few secondary cracks	Interconnected cracks starting to form an alligator pattern , dimensions generally > 12 inch length.	Alligator pattern with dimensions < 12 inch length, or pumping of soil or pieces missing



Extent (feet) Extent may be greater than 500 feet.
Length of cracking in each wheel path.

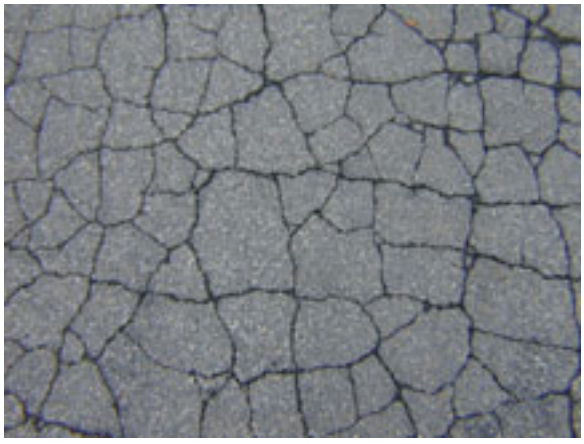


Low Severity	Medium Severity	High Severity
30, 15	40	30

Wheel Path Cracking Photos

Low Severity

Medium Severity

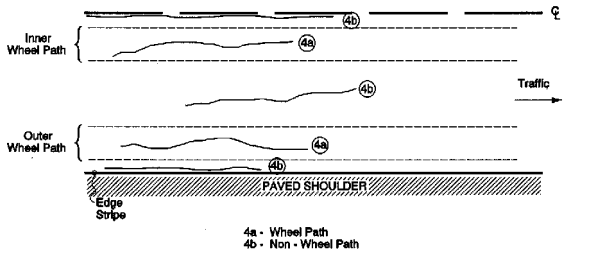


High Severity

Longitudinal Cracking

Description

Non-wheel path longitudinal cracks run roughly parallel to the roadway centerline. These types of cracks are not load-associated. A continuous crack may wonder for short distances into the wheel path; however, if most of its length is outside the wheel path, it is longitudinal. They may be caused by a poorly constructed paving joint, a reflective crack caused by joints and cracks beneath the surface course, including joints and cracks near the edge of the pavement. A **construction edge joint** in the wheel path, without an alligator pattern, shall be rated as a longitudinal crack.

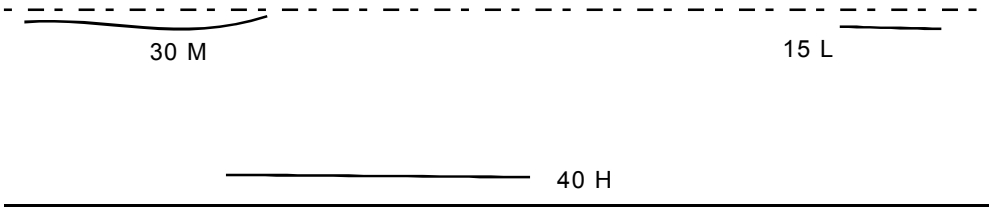


Severity

Its severity is rated according to crack width. See crack width definitions.

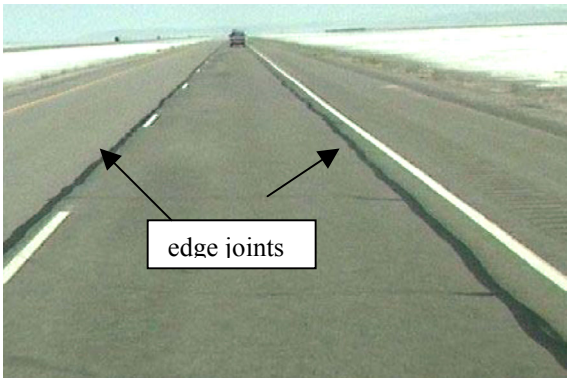
Low Severity	Medium Severity	High Severity
Sealed cracks or unsealed cracks < 3/8" wide	Widths > 3/8" and <3/4" or secondary crack widths <3/8"	Widths > 3/4" or secondary crack widths >3/8"

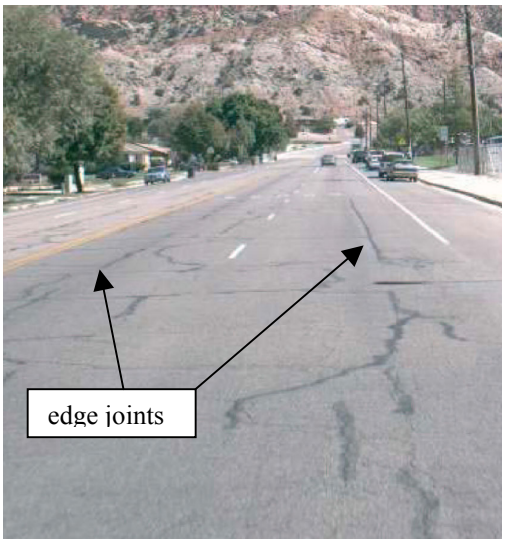
Extent (feet) Extent may be greater than 500 feet.
Total length of cracks in lane. Include cracks along the center line and edge stripe.



Low Severity	Medium Severity	High Severity
15	30	40

Longitudinal Cracking Photos

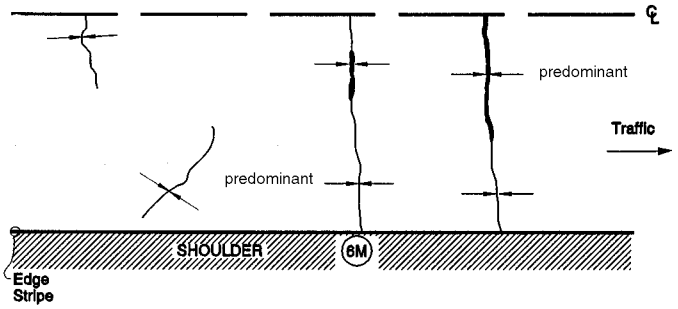




Transverse Cracking

Description

Transverse cracks run roughly perpendicular to the roadway centerline. They may be caused by surface shrinkage due to low temperatures, hardening of the asphalt, or cracks in underlying pavement layers such as PCCP slabs. They may extend partially or fully across the roadway. Record only those transverse cracks that have **a minimum length of four feet.**



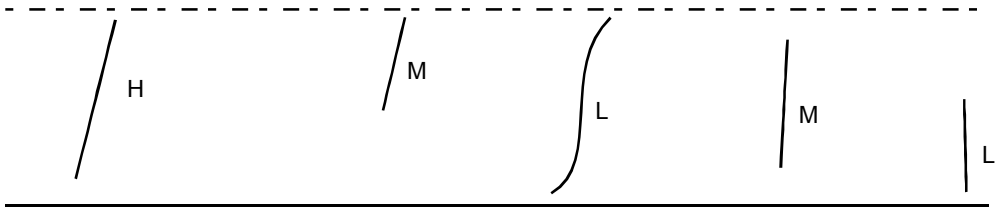
Severity

Its severity is rated according to crack width. See crack width definitions.

Low Severity	Medium Severity	High Severity
Unsealed cracks < 3/8" wide or sealed cracks	Widths > 3/8" and <3/4" or secondary crack widths <3/8"	Widths > 3/4" or secondary crack widths >3/8"

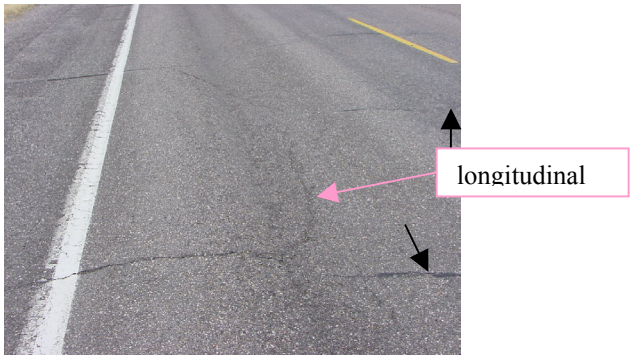
Extent (count)

Number of cracks



Low Severity	Medium Severity	High Severity
2	2	1

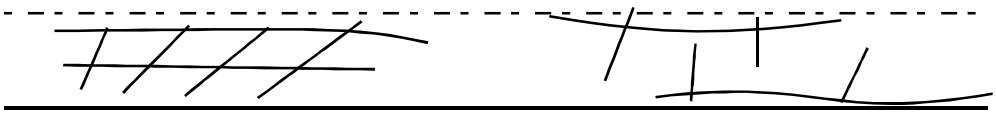
Transverse Cracking Photos



Block Cracking

Description

Block cracks divide the pavement surface into nearly rectangular pieces with cracks that intersect at about 90 degrees. It is caused principally by shrinkage of the asphalt concrete and daily temperature cycling. It is not load-associated, although load can increase the severity of individual cracks. The occurrence of block cracking usually indicates that the asphalt has hardened significantly through aging. Block cracking normally occurs over a large portion of the pavement area including non traffic areas.
To expedite surveying, 2 or more non-wheel path parallel longitudinal cracks and transverse cracks with a spacing of less than 10 feet will be rated as block cracking.



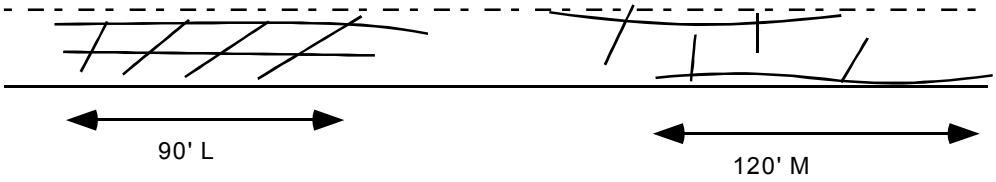
Severity

Its severity is rated according to crack width. See crack width definitions.

Low Severity	Medium Severity	High Severity
Unsealed cracks < 3/8" wide or sealed cracks	Widths > 3/8" and <3/4" or secondary crack widths <3/8"	Widths > 3/4" or secondary crack widths >3/8"

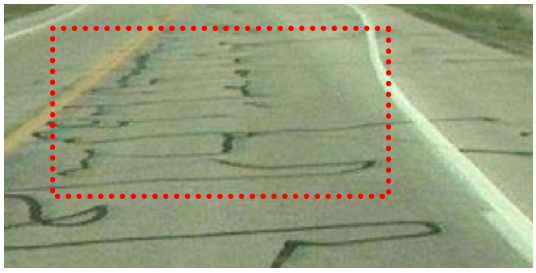
Extent (feet)

Length of survey section that has block cracking. Maximum length is 500 feet.



Low Severity	Medium Severity	High Severity
90	120	

Block Cracking Photos



Do not count transverse cracks or record longitudinal crack lengths in block cracking section

Raveling and Oxidation

Description

Raveling and aging are pavement surface deterioration that occurs when aggregate particles are dislodged (raveling) or oxidation causes loss of the asphalt binder flexibility (aging). Rate the overall severity within the segment as the most predominant observed level. The characteristics of raveling can change with the type of asphalt mix. Hot mix asphalt, an open graded seal coat (plant mix seal coat), and a chip seal can have slightly different appearances. Extreme raveling in chip sealed pavements (loss of aggregate) could result in a condition of excess asphalt, and should be rated as bleeding.

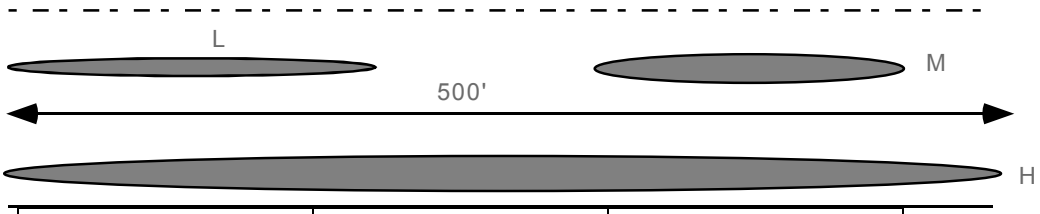
Severity

It is rated by the degree of aggregate and binder loss. Only record the predominant severity.

Low Severity	Medium Severity	High Severity
Asphalt oxidized & minor loss of aggregate	Road surface pitted from loss of aggregate	Surface appears rough with substantial loss of aggregate

Extent (feet)

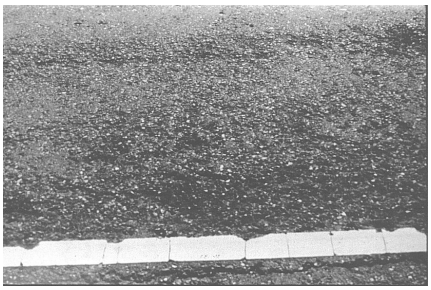
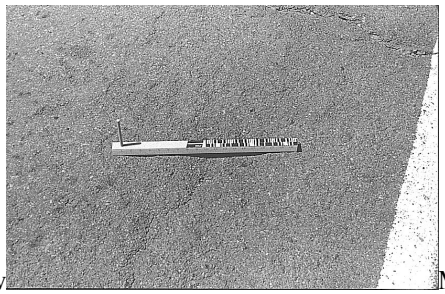
Length of survey section that has any raveling or oxidation. Maximum length is 500 feet.

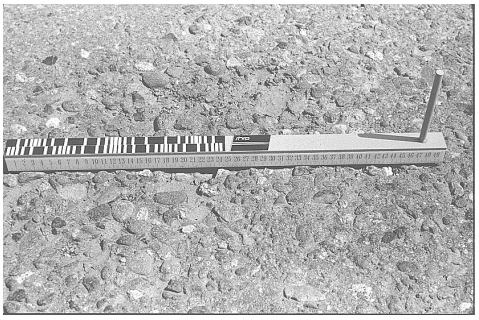


Low Severity	Medium Severity	High Severity
		500 '

Photos of Raveling

Hot Mix Asphalt


Low

Medium


High

Chip Seals

High (recent rejuvenation)

High

Open Graded Surface Course (Plant Mix Seal Coat)

Low

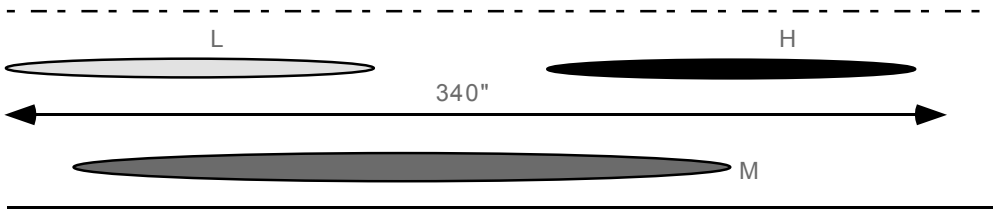
Bleeding

Description
Flushing and bleeding is indicated by an excess of bituminous material on the pavement surface which presents a shiny, glass-like reflective surface that may become sticky in hot temperatures.

Severity
It is determined by the amount of asphalt occurring at the surface of the pavement. Only record the predominant severity.

Low Severity	Medium Severity	High Severity
Surface discolored relative to remainder of pavement	Losing surface texture due to excess asphalt	Shiny appearance due to excess asphalt. Aggregate obscured by excess asphalt

Extent (feet)
Length of survey section that has bleeding. Maximum length is 500 feet.



Low Severity	Medium Severity	High Severity
	340'	

Bleeding Photos

low severity if surface texture is apparent

medium severity if some surface texture is lost

high severity if aggregate obscured by asphalt

Patching

Description
A patch is an area of pavement which has been replaced or locally covered with new material to repair the existing pavement distress or access a utility.

Severity
Not rated.

Extent (feet)
Cumulative length between reference posts that is patched.

Patching Photos

Pot Holes (Optional)

Bowl shaped holes in pavement with a minimum plan dimension of 6 inches. Survey this distress if requested by maintenance.

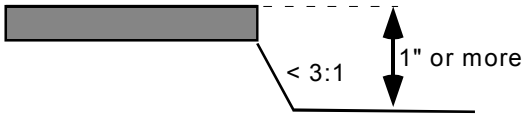
Severity
Not rated.

Extent (number)
Number between reference post at start of survey section and next survey reference post.

Pot Hole Photo

Edge Drop Off (Optional)

Description
A drop in elevation at the outside edge of the pavement that is steeper than 3 (horizontal) to 1 (vertical) and equal to or greater than 1 inch. Survey this condition if requested by maintenance.



Severity
Not rated.

Extent (feet)
Length along 500' survey section or in between reference post at start of survey section and next survey reference post, as determined by maintenance.

Photos

DISTRESS TYPES FOR RIGID PAVEMENTS

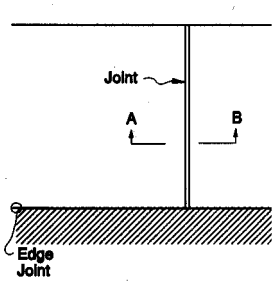
Survey Section: 40 panels or joints

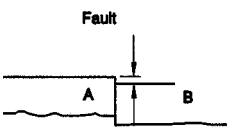
Shattered Slabs
Longitudinal Cracking
Transverse Cracking
Corner Breaks
Surface or Durability Defects
Spalling of Transverse Joints
Joint Seal Damage
Pumping
Edge Drop Off > 1" Steeper than 3:1 (Optional)

Definitions

Spalling is material missing or enclosed by a crack adjacent to a joint or crack.

Faulting is the difference in surface elevation of sides separated by a crack or joint.



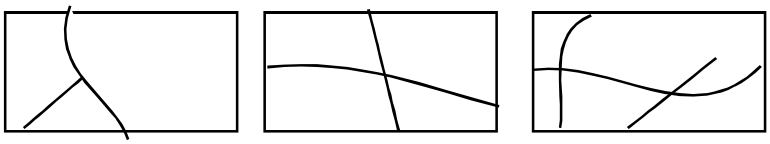


Shattered Panels

Description
The panel is broken into 3 or more **pieces** with boundaries defined by cracks or joints. If a panel is shattered, do not count it as a transverse or longitudinal cracked panel. A corner break is counted as a piece. If a shattered panel has a corner break, do not include panel with corner breaks.

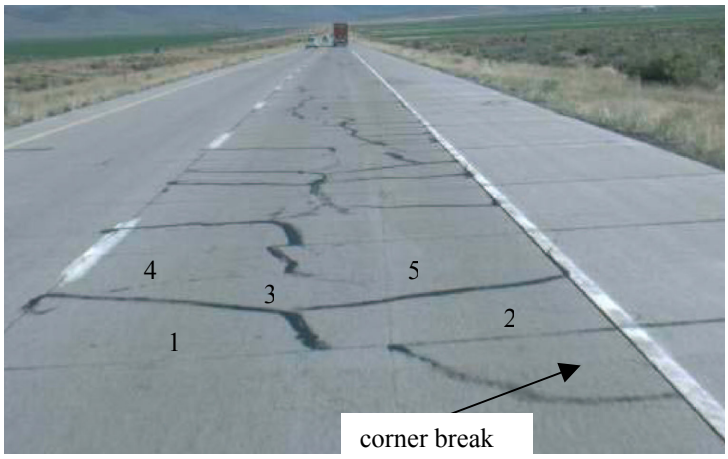
Severity
It is determined by number of pieces.

Low	Medium	High
3 pieces	4 pieces	5 or more pieces



Extent
Number of **panels** that are broken.

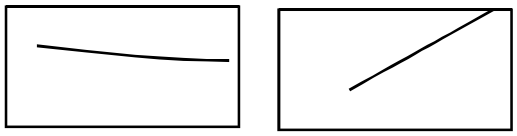
Shattered Panel Photo



Longitudinal or Diagonal Cracks

Description

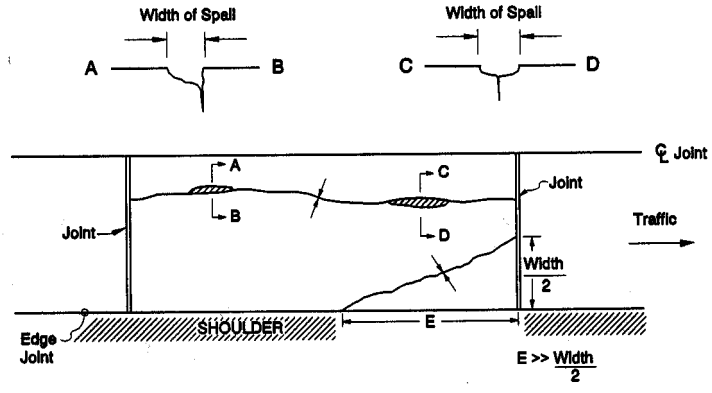
Cracks that predominantly parallel the pavement centerline (longitudinal) or cross the panel at an angle.



Severity

It is determined by crack width, spalling, and faulting.

Low	Medium	High
Crack widths < 1/8", no spalling or faulting	Crack width 1/8" to ½" or faulting < ½", or spalling < 3"	Crack widths > ½" or faulting > ½" or spalling > 3"



Extent

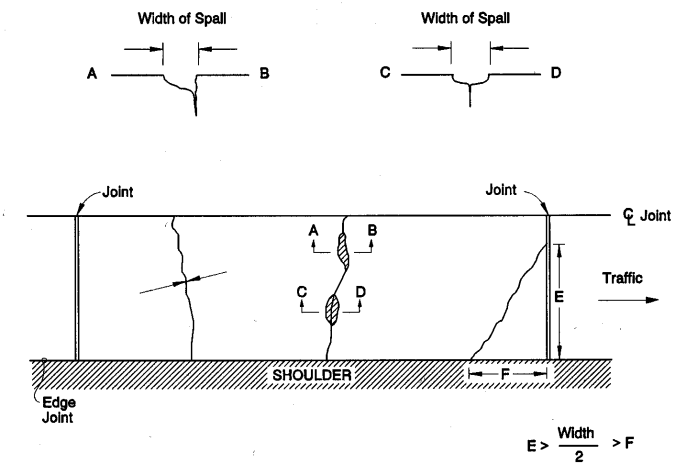
Number of panels that have longitudinal or diagonal cracks.

Longitudinal Crack Photo

Transverse Cracks

Description

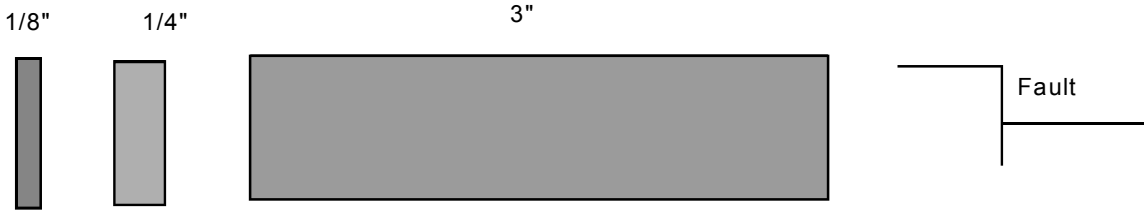
Cracks that are predominantly perpendicular to the pavement centerline.



Severity

It is determined by crack width, spalling, and faulting.

Low	Medium	High
Crack widths < 1/8", no spalling or faulting	Crack width 1/8" to 1/4" or faulting < 1/4", or spalling < 3"	Crack widths > 1/4" or faulting > 1/4" or spalling > 3"



Extent

Number of panels that have transverse cracks.

Transverse Crack Photo

Corner Breaks

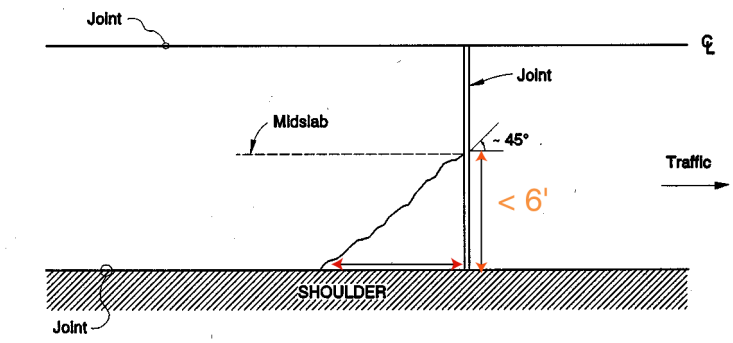
Description

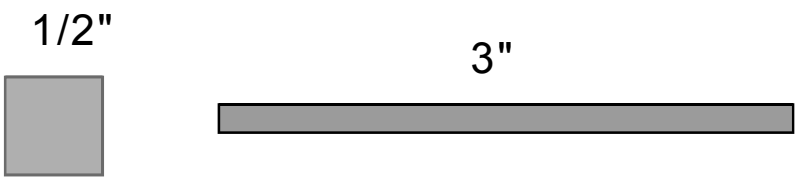
The separation of the corner portion of the slab by a crack that intersects the adjacent transverse and longitudinal joints at approximately a 45 degree angle to the direction of traffic. The minimum length of a side is 1 foot. The maximum length of a side is 6 feet. If the length exceeds 6 feet it is rated as a longitudinal crack. The crack extends through the entire depth of the slab allowing the corner to move independently.

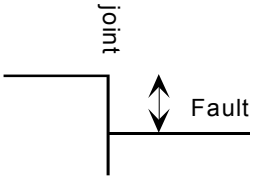
Severity

It is determined by the number of pieces, spalling, or faulting.

Low	Medium	High
one piece and no spalling or faulting	one piece and spalling < 3" or faulting < 1/2"	two or more pieces or spalling > 3" or faulting > 1/2"



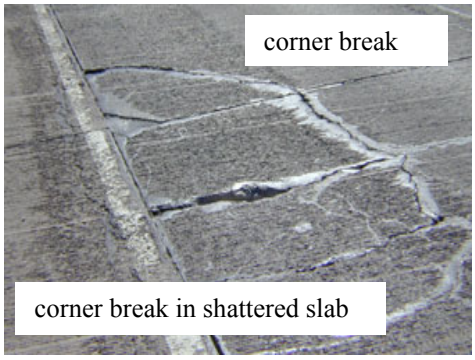




Extent

Number of panels that have corner breaks.

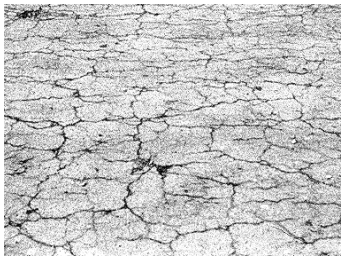
Corner Break Photos



Surface or Durability Defects

Scaling: Loss of surface motar from the pavement surface. Diminsions greater than 1".

Map Cracking: A chicken wire pattern of shallow hairline cracks.



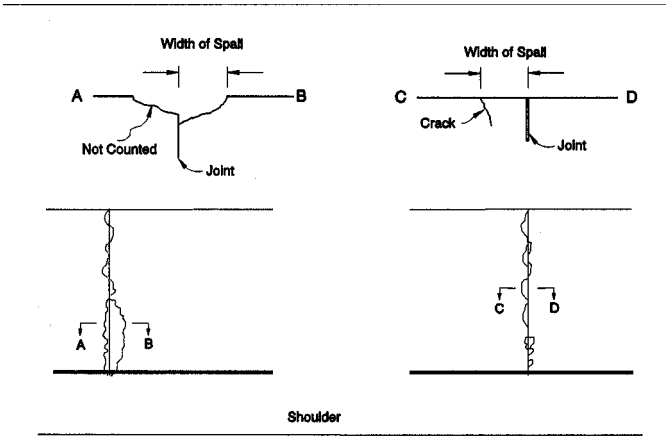
"D" Cracking: Closely spaced hairline cracks parallel and adjacent to joints or cracks. Some discoloration may occur.

Extent
Number of panels that have each defect.

Spalling of Transverse Joints

Description

One or more spalls on a transverse joint. A spall is continuous cracking or chipping back from the joint that forms an arc.



Severity

It is determined by the spall width extending out from the center of the joint.

Low	Medium	High
Spalling < 3" wide.	Spalling 3" to 6" wide.	Spalling > 6" wide.

Extent

Number of joints that have spalls.

Joint Spall Photos

Transverse Joints with Seal Damage (Optional)

Description
Transverse joints with more than 2 feet of length that appears to be separated from the concrete edges or sunken.

Severity
Not rated

Extent
Number of joints that have seal damage.

Joint Seal Photos

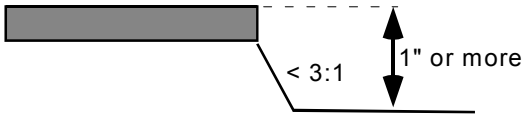




Seal undamaged

Edge Drop Off (Optional)

Description
A drop in elevation at the outside edge of the pavement that is **steeper** than 3 (horizontal) to 1 (vertical) and equal to or greater than 1 inch. Survey this condition if requested by maintenance.



Severity
Not rated.

Extent (feet)
Length along 500' survey section or in between reference post at start of survey section and next survey reference post, as determined by maintenance.

Pumping

Description
The occurrence of underlying base material fines on the surface of the pavement along transverse joints near the edge of the outside travel lane. The transverse joint will be faulted. The combination of joint movement from traffic loading and water at the base of the pavement brings the fines to the surface at the joints.

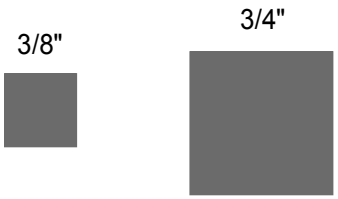
Severity
Not rated.

Extent
Yes or No

Route _____ **Direction** _____ **Date** _____

RP _____ **Offset (feet)** _____ **Survey By** _____

Asphalt Distress Type	Extent	Low Severity	Medium Severity	High Severity	Comments
Wheel Path Cracking*	Linear Feet	Longitudinal cracks with no or only a few secondary cracks	Interconnected cracks forming a chicken wire/ alligator pattern	Alligator pattern with pumping of soil or pieces missing	
Block Cracking*	Linear Feet	Cracks sealed 80% of length or unsealed cracks < 3/8"	between 3/8" and 3/4" or secondary cracks <3/8"	> 3/4" or secondary cracks >3/8"	
Longitudinal Cracking (Non Wheel Path or Construction Joint)*	Linear Feet	Cracks sealed 80% of length or unsealed cracks < 3/8"	between 3/8" and 3/4" or secondary cracks <3/8"	> 3/4" or secondary cracks >3/8"	
Transverse Cracking*	Number of cracks greater than 4 foot length	Cracks sealed 80% of length or unsealed cracks < 3/8"	between 3/8" and 3/4" or secondary cracks <3/8"	> 3/4" or secondary cracks >3/8"	
		Predominant Severity			
Bleeding	Length (feet) of survey section	Surface discolored relative to remainder of pavement	Losing surface texture due to excess asphalt	Shiny appearance due to excess asphalt. Aggregate obscured by excess asphalt	
		Predominant Severity			
Oxidation & Raveling	Length (feet) of survey section	Asphalt oxidized & minor loss of aggregate	road surface pitted from loss of aggregate	Surface appears rough and substantial loss of aggregate	
Edge Drop Off > 1" Steeper than 3:1 (OPTIONAL)	Length (feet): in survey section or between RPs				
Skin Patching	Length (feet):between RPs				
Potholes (OPTIONAL)	Number > 6" Diameter between RPs				
Some Cracks Sealed	Check if Yes				



NOTE: *Distresses that are measured at each severity level.

Example

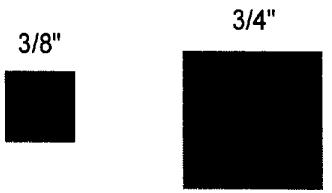
Route 57 Direction (+) Date 9/23/02

RP 14 Offset (feet) RP+600' Survey By J. Smith

Structure

Asphalt Distress Type	Extent	Low Severity	Medium Severity	High Severity	Comments
Wheel Path Cracking*	Linear Feet	Longitudinal cracks with no or only a few secondary cracks	Interconnected cracks forming a chicken wire/ alligator pattern	Alligator pattern with pumping of soil or pieces missing	
		30, 60, 200	20		
Block Cracking*	Linear Feet	Cracks sealed 80% of length or unsealed cracks < 3/8"	between 3/8" and 3/4" or secondary cracks <3/8"	> 3/4" or secondary cracks >3/8"	
		40			
Longitudinal Cracking (Non Wheel Path or Construction Joint)*	Linear Feet	Cracks sealed 80% of length or unsealed cracks < 3/8"	between 3/8" and 3/4" or secondary cracks <3/8"	> 3/4" or secondary cracks >3/8"	
Transverse Cracking*	Number of cracks greater than 4 foot length	Cracks sealed 80% of length or unsealed cracks < 3/8"	between 3/8" and 3/4" or secondary cracks <3/8"	> 3/4" or secondary cracks >3/8"	
		~~HHT~~ III	III	I	
		Predominant Severity			
Bleeding	Length (feet) of survey section	Surface discolored relative to remainder of pavement	Losing surface texture due to excess asphalt	Shiny appearance due to excess asphalt. Aggregate obscured by excess asphalt	
		Predominant Severity			
Oxidation & Raveling	Length (feet) of survey section	Asphalt oxidized & minor loss of aggregate	road surface pitted from loss of aggregate	Surface appears rough and substantial loss of aggregate	
		500			
Edge Drop Off > 1" Steeper than 3:1 (OPTIONAL)	Length (feet): in survey section or between RPs	300			
Skin Patching	Length (feet):between RPs	400, 1000, 300,			
Potholes (OPTIONAL)	Number > 6" Diameter between RPs	1			
Some Cracks Sealed	Check if Yes	✓			

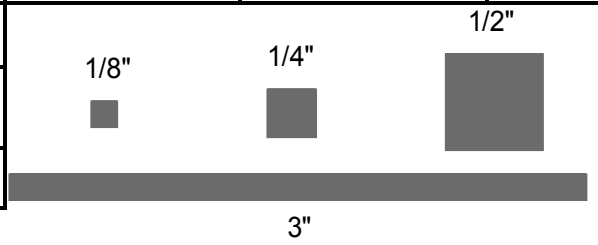
NOTE: *Distresses that are measured at each severity level.



Route _____ **Direction** _____ **Date** _____

RP _____ **Offset (feet)** _____ **Survey By** _____

PCC Distress Type	Measurement Units	Low Severity	Medium Severity	High Severity	Comments
Shattered Slabs	Number of slabs affected.	Slab broken into 3 pieces.	Slab broken into 4 pieces.	Slab broken into 5 or more pieces.	
Longitudinal Cracking	Number of slabs with one or more longitudinal cracks.	Crack widths < 1/8", no spalling or faulting	Crack width 1/8" to ½" or faulting < ½", or spalling < 3"	Crack widths > ½" or faulting > ½" or spalling > 3"	
Transverse Cracking	Number of slabs with one or more transverse cracks.	Crack widths < 1/8", no spalling or faulting	Crack width 1/8" to 1/4" or faulting < 1/4", or spalling < 3"	Crack widths > 1/4" or faulting > 1/4" or spalling > 3"	
Corner Breaks	Number of slabs with one or more corner breaks.	one piece and no spalling or faulting	one piece and spalling < 3" or faulting < 1/2"	two or more pieces or spalling > 3" or faulting > 1/2"	
Surface or Durability Defects	Number of slabs affected.	Scaling	Map cracking	D Cracking	
Spalling of Transverse Joints	Number of transverse joints affected.	Spalling < 3" wide.	Spalls 3" to 6" wide.	Spalls > 6" wide.	
Joint Seal Damage (OPTIONAL)	Number of transverse joints with > 2' damaged				
Edge Drop Off > 1" Steeper than 3:1 (OPTIONAL)	Length (feet): in survey section or between RPs				
Pumping	Check if Yes				



Example

Route 13 Direction (-) Date 9/23/02

RP 5 Offset (feet) Survey By J. Jones

PCC Distress Type	Measurement Units	Low Severity	Medium Severity	High Severity	Comments
Shattered Slabs	Number of slabs affected.	Slab broken into 3 pieces.	Slab broken into 4 pieces.	Slab broken into 5 or more pieces.	
		////		//	
Longitudinal Cracking	Number of slabs with one or more longitudinal cracks.	Crack widths < 1/8", no spalling or faulting	Crack width 1/8" to ½" or faulting < ½", or spalling < 3"	Crack widths > ½" or faulting > ½" or spalling > 3"	
		//			
Transverse Cracking	Number of slabs with one or more transverse cracks.	Crack widths < 1/8", no spalling or faulting	Crack width 1/8" to 1/4" or faulting < 1/4", or spalling < 3"	Crack widths > 1/4" or faulting > 1/4" or spalling > 3"	
		//// /	////		
Corner Breaks	Number of slabs with one or more corner breaks.	one piece and no spalling or faulting	one piece and spalling < 3" or faulting < 1/2"	two or more pieces or spalling > 3" or faulting > 1/2"	
				/	
Surface or Duribility Defects	Number of slabs affected.	Scaling	Map cracking	D Cracking	
			//		
Spalling of Transverse Joints	Number of transverse joints affected.	Spalling < 3" wide.	Spalls 3" to 6" wide.	Spalls > 6" wide.	
		//// //		//	
Joint Seal Damage (OPTIONAL)	Number of transverse joints with > 2' damaged	//// //// //// //// ///			
Edge Drop Off > 1" Steeper than 3:1 (OPTIONAL)	Length (feet): in survey section or between RPs	200, 400, 600, 900